THE WEATHER AND CIRCULATION OF JANUARY 1966

A Temperature Pattern Reversal Associated With an Index Cycle

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1. HIGHLIGHTS

The temperature regime in the United States during January was in sharp contrast with the December regime. In December only the extreme east and west coasts had temperatures that were near or below normal. Elsewhere in the country during December temperatures were above normal with the greatest anomalous warmth observed in the central part of the Nation [1]. However, in January most of the United States experienced below normal temperatures with the near or above normal temperatures restricted to the Northeast and parts of the Far West. This reversal of the temperature regime was associated with an index cycle such as described by Namias [2,3,4].

The major thrust of the cold wave which came late in January was associated with blizzard conditions over the Appalachians and east coastal areas. Very widespread snowfall occurred with several storms, and only in the southernmost States did the ground remain free of snow at the end of the month (fig. 1).

2. MEAN CIRCULATION

The 700-mb. flow at the beginning of January was one of quite high zonal index for middle latitudes of the Western Hemisphere, but this index dropped steadily reaching a rather low value in the latter half of the month (fig. 2). This resulted in a mean monthly circulation with an average westerly wind speed in the area bounded by 35°–55° N. and 5°–175° W. that was only 0.2 m.p.s. below normal. However, a cursory examination of figures 3 and 4 will show that the average wind speed at mid dle latitudes does little to describe the cir

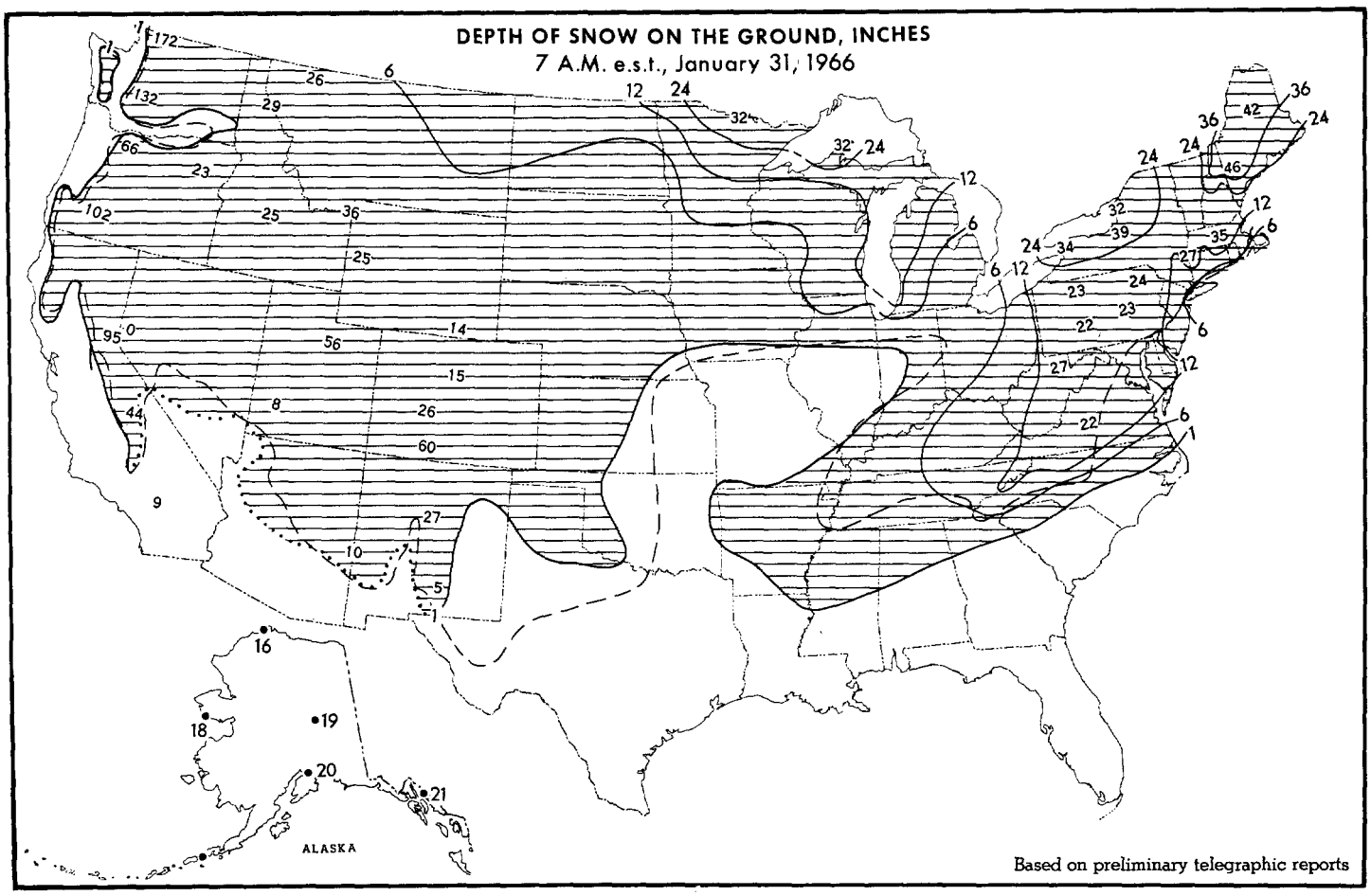
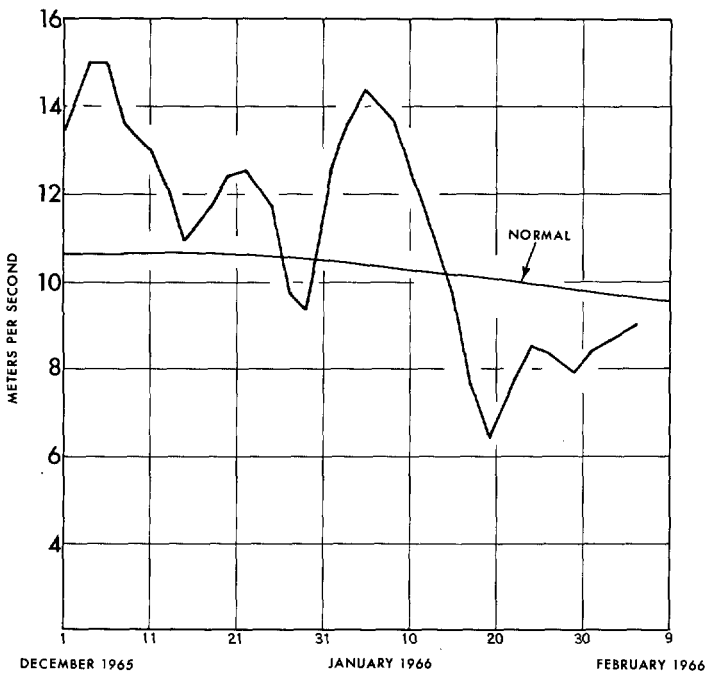


FIGURE 1.—Depth of snow on the ground in inches at 7 a.m. EST, January 31, 1966 (from [5]).



culation over the Western Hemisphere. The anomalous 700-mb. heights over the Atlantic and North America (fig. 4) represent an extremely strong and complex blocking situation, which caused a reversal of weather regimes in the United States.

Although no zonal index was computed for the remainder of the Northern Hemisphere, the general appearance of the anomalous flow in figure 4 is meridional over most of Asia and much of Europe, indicating a tendency for blocking over Eurasia also. The mean low pressure area in the Pacific near Kamchatka was close to its normal position, but this Low was deeper than usual, reflecting the frequent and intense cyclonic activity that occurred in the Pacific.

Another illustration of the complexity of the 700-mb.

FIGURE 2.—Variations of 5-day average wind speed (zonal index, meters per second) at 700 mb. for the western half of the Northern Hemisphere, 35° to 55° N., from December 1, 1965 to early February 1966. Solid line connects values at the middle of 5-day periods; dashed line is the normal.

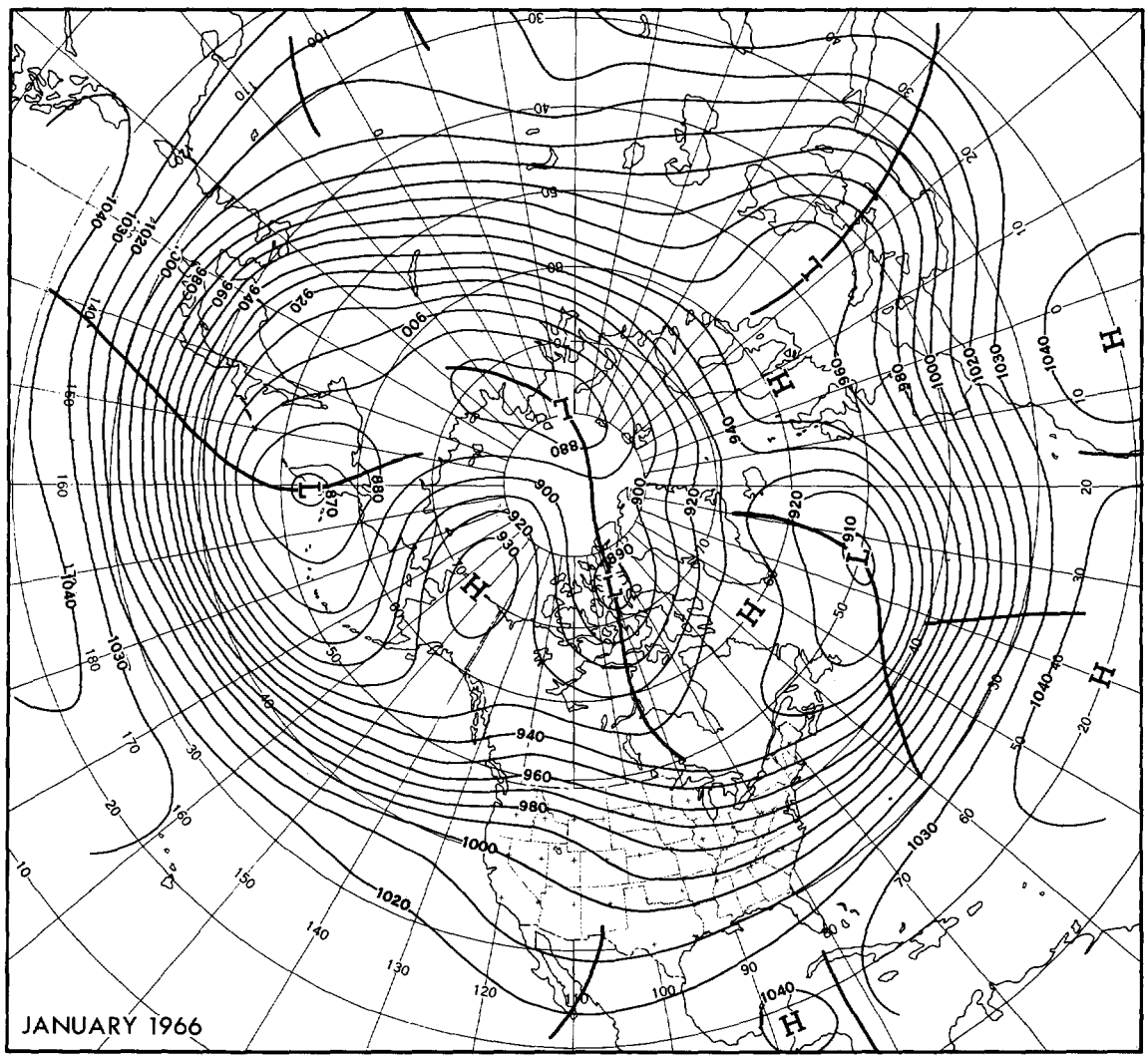


FIGURE 3.—Mean 700-mb. contours (tens of feet), January 1966. A complicated blocking pattern prevailed over the Atlantic and North America.

flow during January is shown in figure 5. In some areas around the globe the westerlies were split into three separate branches instead of the usual one or two. The very strong jet maximum in the Pacific was a continuation of the December regime in that area [1].

3. INDEX CYCLE

The index cycle that began this month seemed to follow the classical pattern as described by Namias [2]. The warmth in the United States during December [1] and also the relatively high index situation (fig. 2) indicated that the cold air in the Arctic was being contained, at least in much of the western Hemisphere. To quote Namias: "... the intensity of long index cycles is largely determined by the reservoir of cold air preceding their onset." Another requirement that Namias postulated for a major index cycle was a triggering mechanism, a blocking wave. The blocking surge in this instance first appeared over Scandinavia and then moved westward across Greenland into North America (see figs. 9–12). As the index cycle progressed, the major band of zonal westerlies was displaced farther south each week. Figure 6 shows four 5-day mean wind speed profiles for periods spread nearly evenly through the month. These profiles indicate the gradual southward progression of the major westerlies across the Atlantic and North America. At the same time, the 700-mb. westerlies at very high latitudes changed to easterlies as a major mid-tropospheric anticyclone became established near the North Pole late in the month.

An examination of figure 2 alone does not indicate when the expanded westerly band began to relax and return to normal. The middle latitude zonal index reached its lowest point on the 19th, but the profiles in figure 6 clearly show that the strongest westerlies were farther south during the final week of January than during any earlier week of the month.

4. TEMPERATURE

Extensive cold air in the United States during January (fig. 7) can be attributed to the strength of the upper-level ridge extending northward from Alaska (fig. 3) which was in phase with the lower-latitude ridge over the western United States. This ridge combination along with the trough in the East thrust a series of very cold surface air masses southward over most of the United States. Anomalous snow cover that extended quite far south (fig. 1) contributed to the persistence and severity of the cold.

Warmth in the Northwest was associated with the trajectory of the Pacific air arriving in that area. Although the mean flow in the immediate vicinity of the observed warmth had very little southerly component and the observed 700-mb. heights were very near normal (figs. 3 and 4), the long southwesterly fetch offshore brought the warmer air inland in the Northwest as far as western Montana and Wyoming. The occurrence of above normal temperature in the extreme Northeast was a reflection of the strong east-northeast anomalous flow that brought relatively mild maritime air into Maine.

5. PRECIPITATION

The area of heavy precipitation in the eastern two-thirds of the United States (fig. 7) can best be attributed to the

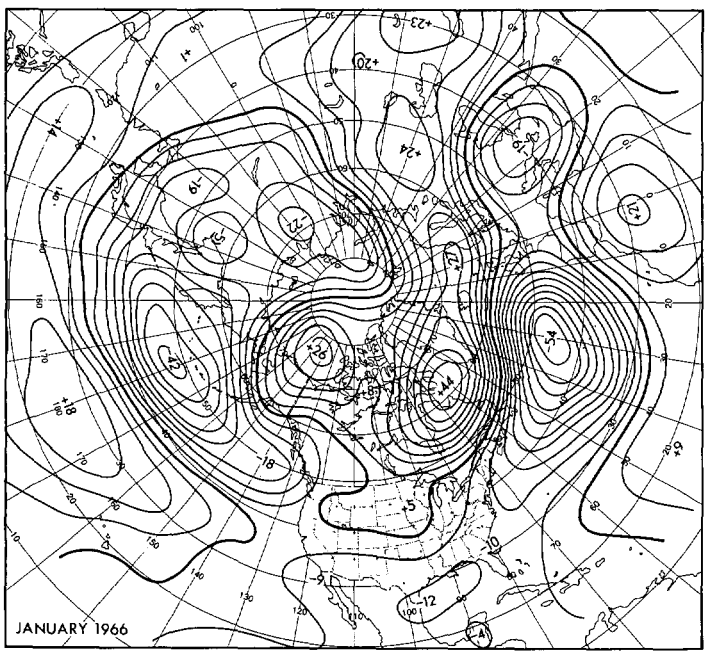


FIGURE 4.—Departure of mean 700-mb. heights from normal (tens of feet), January 1966. Strong centers of positive anomaly dominated high latitudes in association with blocking.

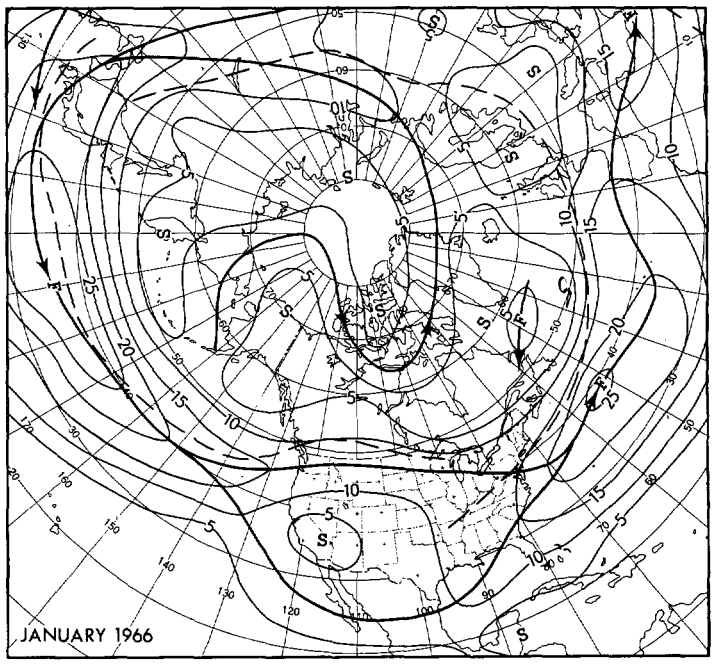


FIGURE 5.—Mean 700-mb. isotachs (meters per second), January 1966. Solid arrows indicate principal axes of maximum wind speed and dashed lines the normal. Wind speed maxima over both oceans were stronger than normal with the Atlantic jet displaced south of normal.

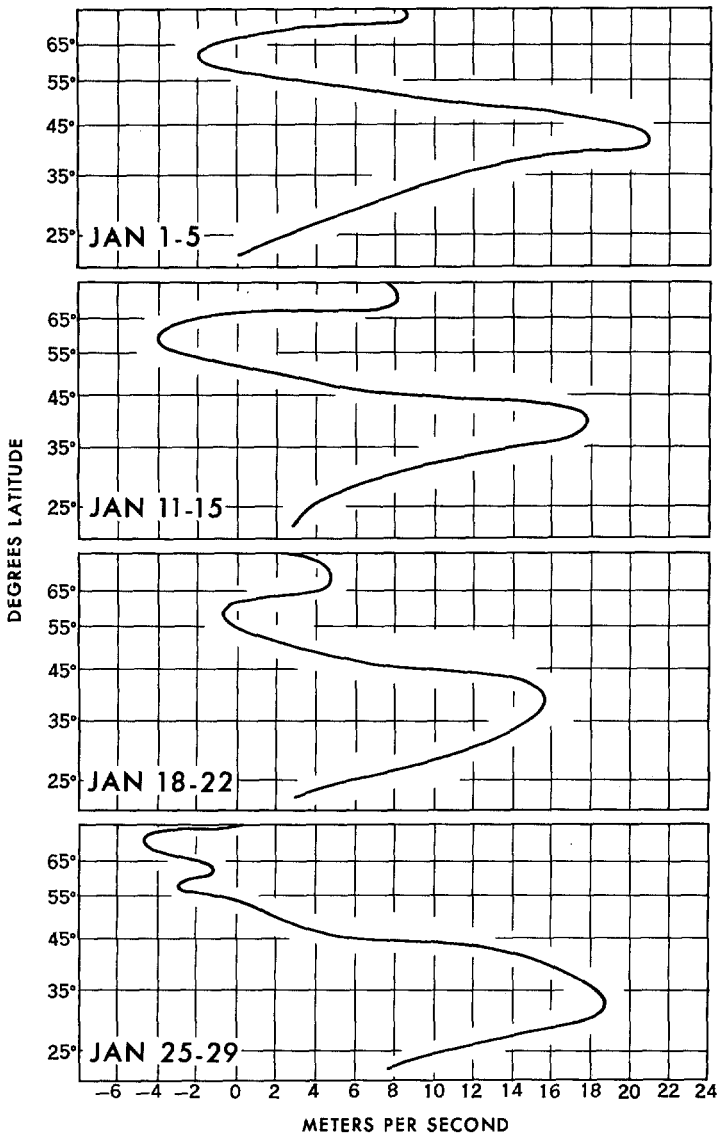


FIGURE 6.—Four 5-day mean zonal wind speed profiles for the western half of the Northern Hemisphere, January 1966. The main band of westerlies gradually moved southward.

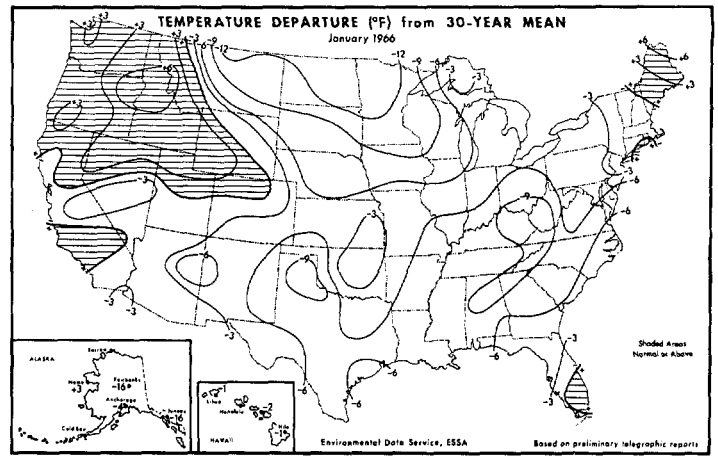


FIGURE 7.—Surface temperature departure from normal (° F.), January 1966 (from [5]).

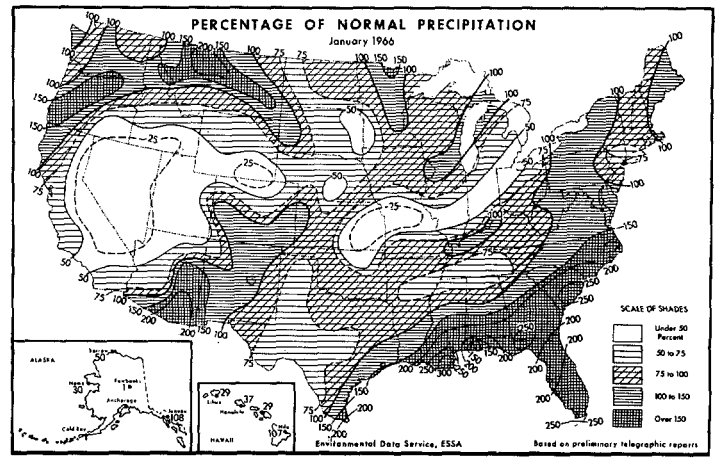


FIGURE 8.—Percentage of normal precipitation, January 1966 (from [5]).

TABLE 1.—*Snowfall totals for January 1966.*

Location	Monthly snowfall (in.)	Remarks
Concord, N.H.	32.9	Heaviest January snowfall since 1935.
Binghamton, N.Y.	36.6	Greatest January snowfall since 1945.
Buffalo, N.Y.	48.0	2d greatest January snowfall.
Rochester, N.Y.	60.2	Record January snowfall.
Syracuse, N.Y.	71.0	Record January snowfall.
Caribou, Maine	38.2	Snowiest January since 1935.
Worcester, Mass.	40.0	Record January snowfall.
Greensboro, N.C.	22.9	Record snowfall for any month.
Greenville, S.C.	9.1	Snowiest January in over 60 years.
Lynchburg, Va.	31.8	Record monthly snowfall.
Richmond, Va.	26.2	2d greatest monthly snowfall.
Roanoke, Va.	41.2	Greatest monthly snowfall since 1901.

strong blocking pattern and resulting easterly anomalous flow across the country (fig. 4). The precipitation was welcome in the Northeast because of the long term drought [1]. However, some of the drought area had less than normal January precipitation. In the Northwest, the heavy precipitation fell near the main polar jet (fig. 5), which is usual for precipitation regimes in that area.

The extremely heavy precipitation that fell in the Southeast was associated with the expanding westerlies and south-of-normal storm track. Several major storms originated in the Gulf of Mexico during January and moved up the east coast. Because of the extreme cold, the precipitation over the Middle Atlantic States and Northeast was mostly in the form of snow. Record or near record amounts of snow fell during January at many locations from South Carolina to Maine (table 1).

6. VARIABILITY WITHIN THE MONTH

The warm regime of December gave way rather slowly at the begining of January. The appearance early in the month of a strong ridge over Alaska which phased with a lower-latitude ridge in western United States (fig. 9A) did result in cold air entering the Northern Plains in strength during the first week. Early during the second week some of this cold air filtered into the southern States accounting for slightly below normal temperatures in parts of the South (note dates on fig. 9B). However, the position of the western United States ridge and the

positive 700-mb. height anomaly caused temperatures in the West and in much of the Central Plains to remain considerably above normal.

A storm originating in the Gulf of Mexico and moving through the mean trough in the Southeast gave the heavy precipitation in that area (fig. 9C). The heavy west coast precipitation was the result of storminess associated with the deep mean trough off the coast.

The major high-latitude blocking surge that so violently changed the Western Hemispheric circulation during January first appeared early in the month (fig. 9A). A building ridge extending from North Africa developed a 520-ft. positive anomaly center at the 700-mb. level over Scandinavia. Late in the second week of January the Atlantic block had become well established (fig. 10A), and the associated positive height anomaly had spread rapidly westward across Greenland and well into Canada. The concomitant southward displacement of the westerlies from the eastern United States to Spain and North Africa had begun. At the same time the western United States ridge was strengthening and retrograding. The effect of the strong shifts of circulation on temperature in the United States was a rapid lowering in the East (fig. 10B) in response to the increased northwesterly upper-level flow in this section. The strength of the western ridge and associated positive height anomaly continued the warm regime in the West and most of the Plains.

Precipitation on the west coast decreased (fig. 10C) as major westerlies in that area moved northward and the deep mean Low off the coast a week earlier receded to near the Aleutian Chain. But two migratory Lows did move inland near the Canadian-United States border during the week and gave heavy precipitation to parts of Washington. These two relatively weak storms moved southeastward, then eastward after crossing the Rocky Mountains and accounted for the light precipitation in the northern United States. The persistent low-latitude mean trough over the Gulf of Mexico gave birth to another storm late in the week which caused heavy precipitation in the Southeast.

By the third week of January the strong blocking anticyclone was centered over eastern Canada with a 780-ft. positive height anomaly (fig. 11A). The strongest upper-level winds over the United States at this time were along the coast of the Gulf of Mexico, and across the Atlantic a very strong jet was positioned quite far south. At the same time the western ridge retrograded to a position over the Pacific and became full-latitude in extent, reaching from the subtropics to almost the North Pole.

The result of these strong circulation features was to deploy very cold Arctic air over most of the United States (fig. 11B). The only storm of importance in the United States this week started in the westerlies across the Gulf of Mexico. Then, feeding on the sharp temperature gradient between warm oceanic air and the intensely cold air that had already been established over the continent, this storm developed rapidly during the last two days of

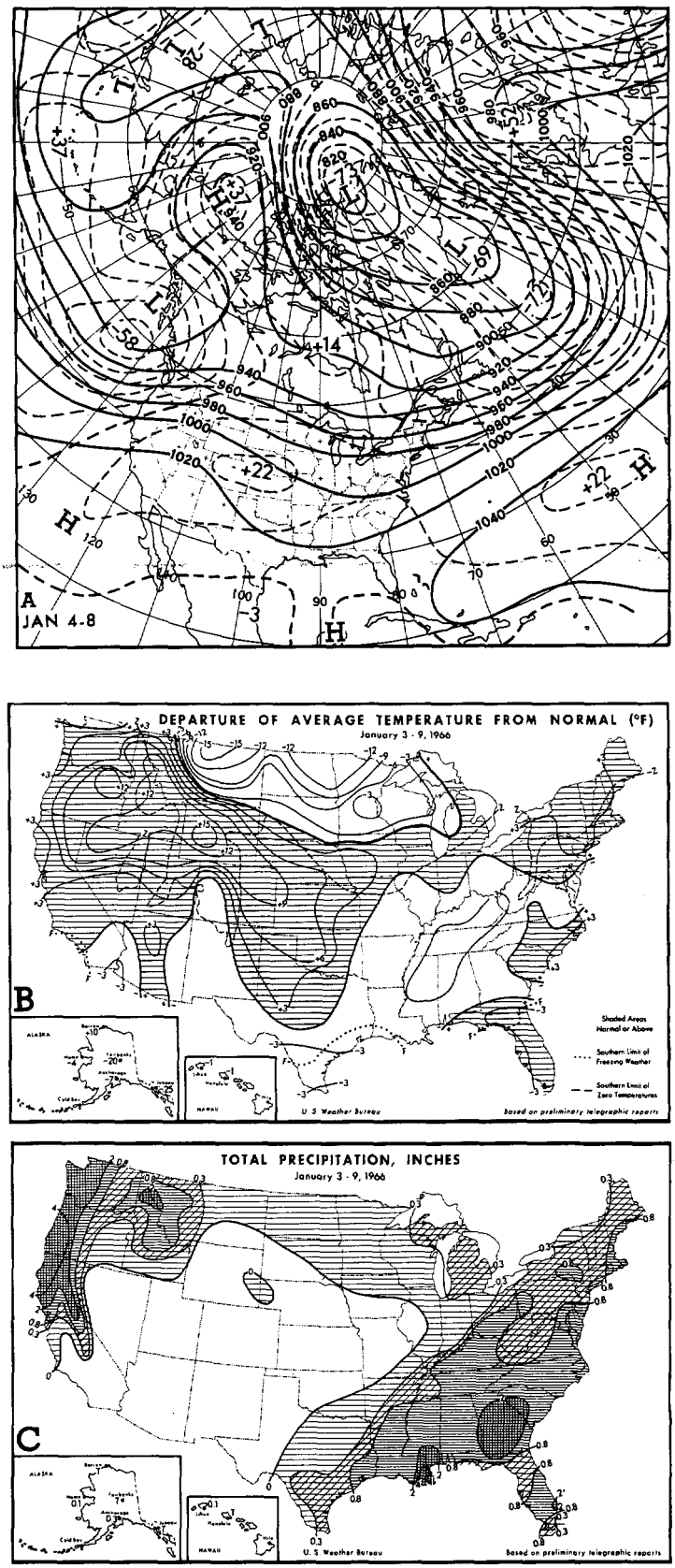
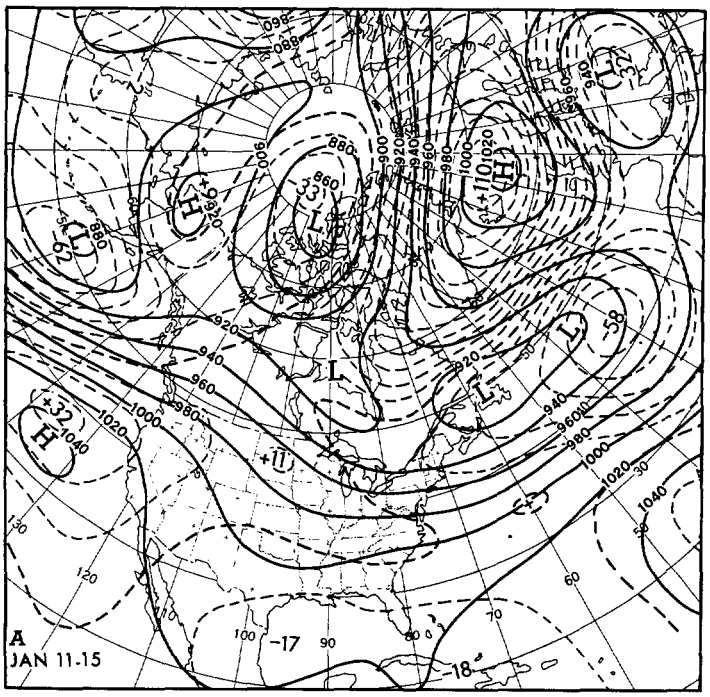
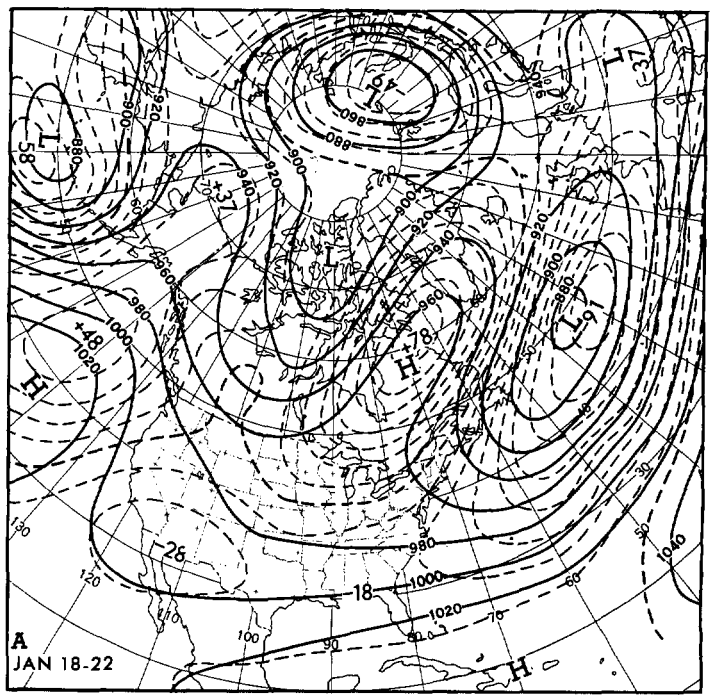
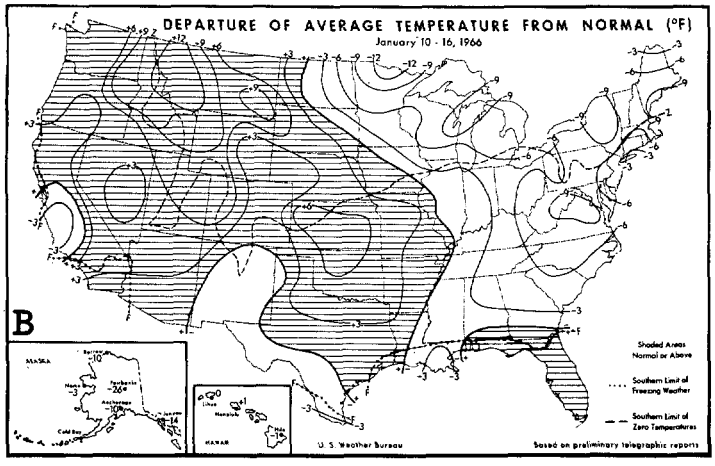
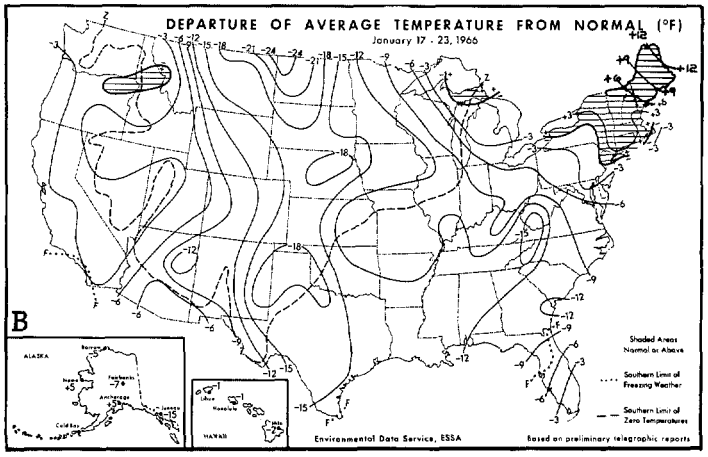


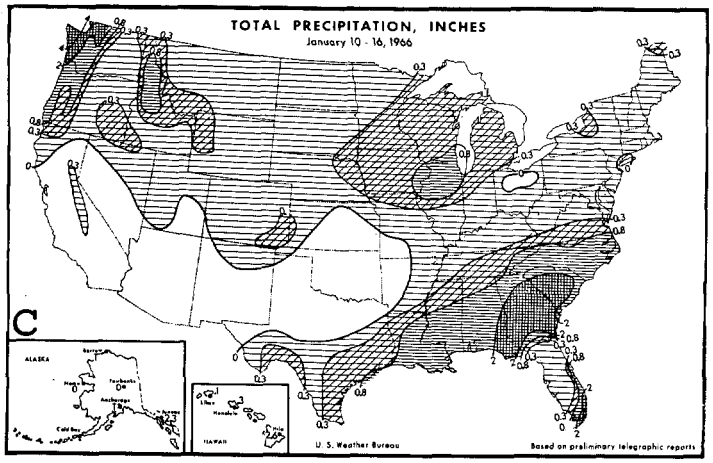
FIGURE 9.—Week of January 3–9, 1966: (A) 700-mb. contours (solid lines) and departure from normal (dashed lines) (both in tens of feet), January 4–8; (B) surface temperature departure from normal (° F.); (C) total precipitation (in.); (B) and (C) from [5].











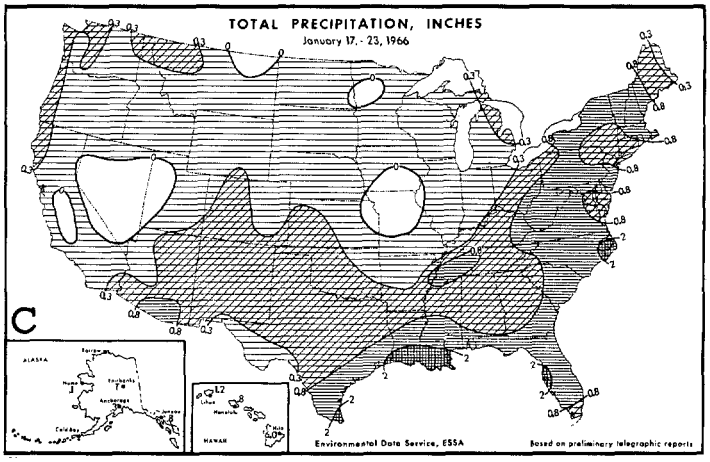


FIGURE 10.—Week of January 10–16, 1966: (A) 700-mb. contours (solid lines) and departure from normal (dashed lines) (both in tens of feet), January 11–15; (B) and (C) as in figure 9.

FIGURE 11.—Week of January 17–23, 1966: (A) 700-mb. contours (solid lines) and departure from normal (dashed lines) (both in tens of feet), January 18–22; (B) and (C) as in figure 9.

the week and moved northeastward along the Atlantic coast. Very large amounts of snow were deposited over the east-central and northeastern States. Figure 11C defines the major outline of the precipitation that fell in this storm.

In the final week of January the middle- and lower-latitude part of the eastern Pacific ridge returned to western United States. The northern part of this ridge sheared and moved toward the North Pole merging with the blocking anticyclone near southern Greenland (fig. 12A). A very strong surface High developed near the pole in association with the upper-level High and slowly spread over most of the North American continent by the end of the week. The result was to intensify the cold wave over the United States (fig. 12B). Progression of the western ridge gave a southerly anomalous flow in the West with sufficient strength to cause surface temperature to be slightly above normal in the Northwest and the Great Basin.

Two more major storms came out of the Gulf of Mexico this week following a path similar to the large storm of the previous week. The last of these storms attained blizzard proportions and was described as "one of the worst blizzard storms in two-thirds of a century" to strike the Appalachians and east coastal areas. Figure 12C shows the amount and extent of the precipitation. The spread of moderately heavy precipitation southward along the west coast was caused by the return of more direct on-shore flow aloft to that region.

7. RELATIONSHIP OF BLIZZARDS TO A CHARACTERISTIC ANOMALOUS 700-MB. HEIGHT PATTERN

The storms of March 1920 and February 1899, as well as the famous blizzard of March 1888, were quite similar to the January 1966 blizzard as to intensity and area affected, although the earlier storms were somewhat farther east.

It is believed that the development of an exceptionally severe snowstorm or blizzard in a certain area of the country tends to be preceded and accompanied by a characteristic 700-mb. height anomaly field. In order to test this hypothesis, an average 700-mb. height anomaly was computed from four 5-day mean 700-mb. height anomalies selected so as to include some of the most recent severe snowstorms and blizzards affecting the northeastern part of the United States. (See fig. 13.)

The February 1958 storm affected most of the Northeast, with heaviest snowfalls from Washington to Boston and inland as far as central New York State. Very low temperatures were observed in the central part of the country, with below normal readings over the entire area east of the Continental Divide [6].

The March 1960 storm occurred within an extremely cold period when nearly the entire country except the far Southwest and northern Maine experienced below normal temperature [7]. Although temperatures in most of the

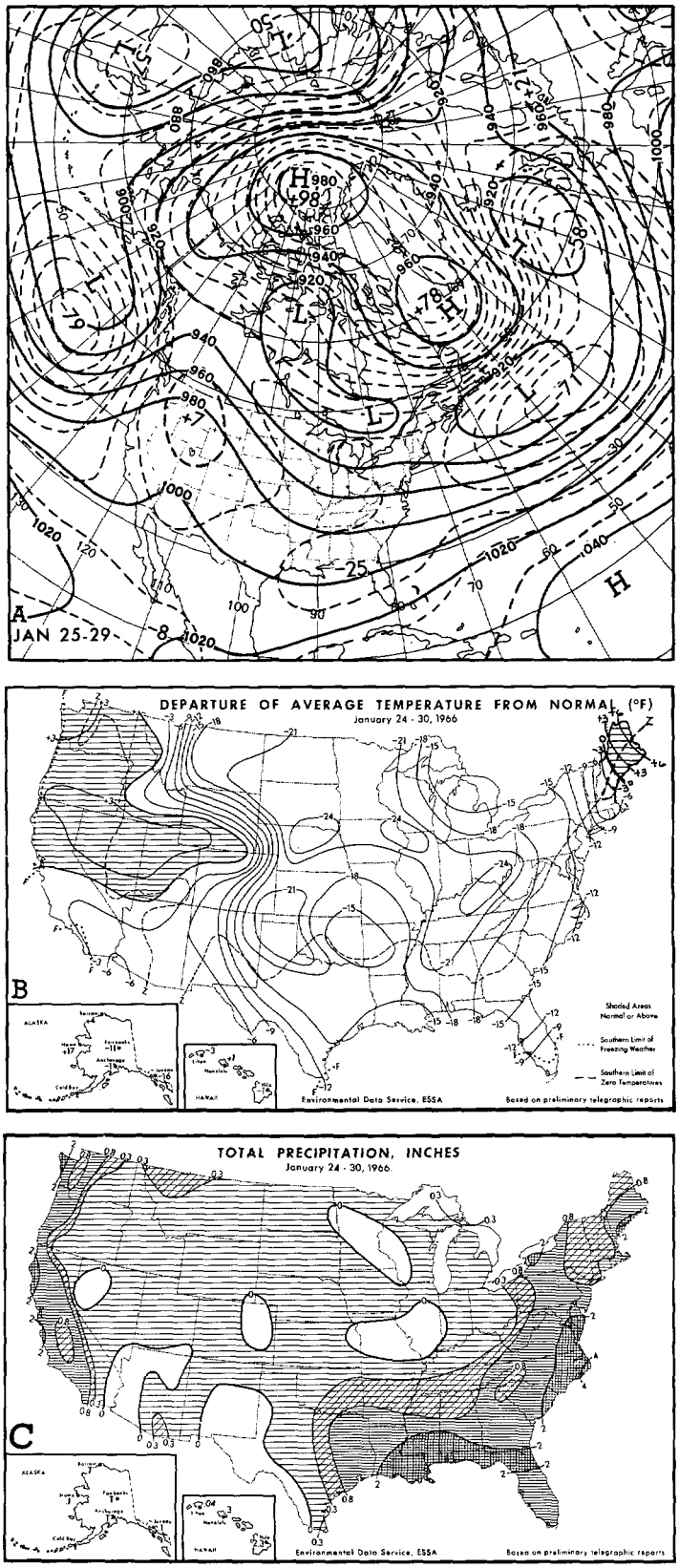


FIGURE 12.—Week of January 24–30, 1966: (A) 700-mb. contours (solid lines) and departure from normal (dashed lines) (both in tens of feet), January 25–29; (B) and (C) as in figure 9.

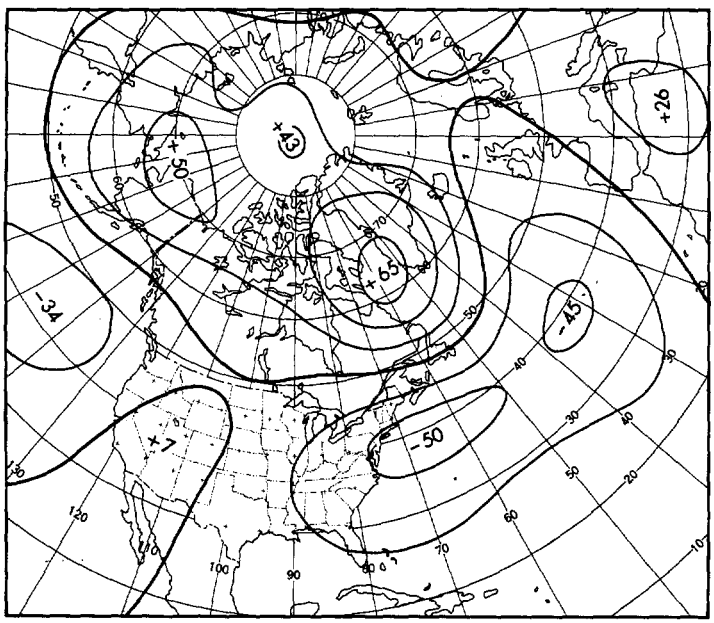


FIGURE 13.—Average of the 5-day mean 700-mb. height departures from normal (tens of feet) for the "northeast blizzard" situations of February 13–17, 1958, March 1–5, 1960, December 29–January 2, 1962–63, and January 27–31, 1966.

storm area were not low enough to make it a true blizzard, snowfall amounts of over 2 ft. were observed in some areas of southeastern New England, along with gale force winds.

The year-end storm of 1962–3 produced severe blizzard conditions over Maine and New Hampshire, and extreme wind-chill over the rest of New England and parts of the mid-Atlantic area, as winds gusting to near hurricane force accompanied sub-zero temperatures. This storm was also preceded by below normal temperatures over most of the country [8].

The heaviest snowfall of a foot or more in the January 1966 blizzard occurred in a belt from Virginia northward through Maryland and Pennsylvania into central New York State, where the Great Lakes lee shore effect combined with the cyclonic circulation to give an almost unbelievable 5-day total of 101 in. of snow at Oswego, N.Y. Many cities recorded storm totals well in excess of a foot, which contributed to the record monthly amounts shown in table 1. Figure 12B shows that very cold air was observed over most of the country in this situation also.

The 1966 storm deepened to below 976 mb. over New England producing gale winds over a wide area, both inland and on the coast. Mild air from the Atlantic turned the snow to rain temporarily over southern New England, thereby considerably reducing accumulations in that area.

A comparison of figures 12A and 13 shows remarkable similarity between the patterns of 700-mb. height anomaly for the 5-day period immediately preceding the January 1966 blizzard and the composite anomaly pattern consisting of the current storm and the previously discussed three recent heavy snowstorms which affected various parts of the Northeast. The similarity seems greater than would be expected merely because the composite includes the January 1966 storm.

The "mean blizzard anomaly pattern" appears to be characterized by above normal heights throughout high latitudes and below normal heights centered near 40° N. latitude over the eastern Pacific and over the entire Atlantic Ocean. This is a characteristic low-index circulation pattern. The largest anomaly in the mean pattern is 650 ft. above normal, located over the Davis Strait. Other positive centers appear near the pole and just north of the Bering Strait. An area of weak positive anomaly is found over the Rockies, and another weak positive center is located over North Africa.

The strongest negative anomaly center is off the Middle Atlantic Coast and of course is contributed to by the storm centers themselves. However, other negative centers over the eastern Pacific and east-central Atlantic show that the blizzard situations are characterized by a southward displacement of the westerlies, particularly over the oceans.

The strong high-latitude blocking and weak anomalous ridge over the western United States combine to deploy cold Arctic air into the central and eastern United States as noted in the discussion of the individual storms. The blocking center over the Davis Strait just 25° north of the negative center off the Atlantic Coast produces a strong anomalous easterly flow from New England northward. This has the effect of increasing the precipitation, both by slowing down the normal eastward motion of storm systems and by advecting moist Atlantic air westward over the cold land areas.

ACKNOWLEDGMENT

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